from which the solitary worker shrinks, but which are, nevertheless, essential to the development of chemistry. Brilliant discoveries might be made in them, but incidentally, and not as their main purpose.

THE table of atomic weights issued annually by the international committee appears in the January number of the *Berichte*, and the table, based upon oxygen = 16, is unaccompanied by the didactic table with hydrogen = 1. The withdrawal of the didactic table is in accordance with a widely expressed wish. It is generally felt that if oxygen is to be taken as 16 for any purpose it should be taken as 16 for all purposes. Discussing this subject in a paper recently contributed to the American Society of Sciences and Arts, Prof. Richards made a strong appeal to chemists to conform to the decision of the international committee. He pointed out that oxygen has actually served as the experimental standard of reference in a great majority of cases, that the great bulk of valuable work has already been published on the basis oxygen = 16·000, and that the use of this standard involves no important didactic difficulties. He contends that the decision of the representatives of the international committee is in itself an important reason for adopting this standard, and that uniformity of usage is more important than any of the special advantages claimed by either side in the discussion. The only alterations of atomic weights in this year's table are of calcium from 40 to 40·1, iron from 56 to 55·9, and tellurium from 127 to 127·6.

THE additions to the Zoological Society's Gardens during the past week include two Guinea Baboons (*Cynocephalus sphinx*), a Red-footed Ground Squirrel (*Xerus erythropus*) from West Africa, presented by Captain R. H. Wilford; a Snow Leopard (*Felis uncia*) from Northern India, presented by Captain H. Nicholl; two Half-collared Turtle Doves (*Turtur semitorquatus*) from West Africa, presented by Captain Thorne; a Ring-necked Pheasant (*Phasianus torquatus*) from China, presented by Mr. B. Tufnell; seven Black-headed Gulls (*Larus ridibundus*), a Common Gull (*Larus canus*), European, presented by Mr. E. J. W. Eldred; a Green Monkey (*Cercopithecus callitrichus*), an Erxleben's Monkey (*Cercopithecus erxlebeni*), eight West African Love-Birds (*Agapornis pullaria*) from West Africa, a Greater Sulphur-crested Cockatoo (*Cacatua galerita*) from Australia, a Levaillant's Amazon (*Chrysotis levaillanti*) from Mexico, ten Common Toads (*Bufo vulgaris*), European, a Loggerhead Turtle (*Thalassochelys caretta*) from Tropical Seas.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN MARCH.

Mar. 3. 22h. Vesta in conjunction with the moon. Vesta 0° 35′ S.
5. 15h. Saturn in conjunction with the moon. Saturn 5° 1′ S.
6. 14h. Jupiter in conjunction with the moon. Jupiter 5° 41′ S.
7. 7h. Venus in conjunction with the moon. Venus 2° 11′ N.
12. 10h. 12m. Minimum of Algol (β Persei).
15. 7h. 1m. Minimum of Algol (β Persei).
15. Venus. Illuminated portion of disc = 0·198, Mars = 1·000.
17. 2h. 0m. Mercury at greatest elongation (27° 41′ W.).
17. 9h. 19m. to 10h. 16m. Moon occults 26 Geminorum (mag. 5·1).
18. 5h. 48m. to 6h. 14m. Moon occults 68 Geminorum (mag. 5·0).
18. 15h. 19m. to 18h. 58m. Transit of Jupiter's Sat. III.
20. 8h. 27m. to 9h. 43m. Moon occults ω Leonis (mag. 5·6).
20. 19h. 0m. Venus at maximum brilliancy.
Mar. 21. 1h. 0m. Sun enters Aries. Spring commences.
21. Saturn. Outer minor axis of outer ring = 13″·75.
22. 11h. 19m. to 12h. 24m. Moon occults p^5 Leonis (mag. 5·5).
28. 13h. 41m. to 15h. 0m. Moon occults ν Scorpii (mag. 4·5).
29. 13h. Mars in conjunction with sun.

OBSERVATIONS OF 900 DOUBLE AND MULTIPLE STARS.—The first of the astronomical series of publications from the University of Pennsylvania consists of the measures of 900 double and multiple stars made by Prof. Doolittle with the 18-inch refractor of the Flower Observatory. These observations were made during the period 1897 January 1 and 1900 October 15. In all cases a power of 592 diameters was employed. Twenty-two of the stars are now catalogued for the first time, having been discovered during the observation of neighbouring doubles.

The 18-inch objective is the largest lens made by Brashear up to the present time, and has given every satisfaction, both as to resolving and light-grasping power. The mounting, by Warner and Swasey, is of similar construction to the Lick and Yerkes instruments (*Publications of the University of Pennsylvania, Astronomical Series*, vol. i. part iii.)

OBSERVATIONS OF 194 DOUBLE STARS.—*Bulletin* No. 11 from the Lick Observatory contains a list of observations made by Mr. R. G. Aitken during 1900 and 1901 with the 36-inch and 12-inch refractors. Many of the stars are difficult pairs, and in most cases the 36-inch telescope was employed, with powers ranging from 1000–2400.

RADIO-ACTIVITY AND THE ELECTRON THEORY.[1]

ELECTRONS emanating from radio-active bodies behave like material particles, and are impeded by the molecules of the surrounding medium, in contrast with ether waves, which are not thus affected except by absorption. It is not difficult to put these indications to test. A pair of shallow cells, A B (Fig. 1), 1·5 mm. deep and 25 mm. square, were made by cementing slips of glass to a thick glass plate. The cells were filled to the same depth with a radio-active substance chiefly containing actinium.[2] Over cell A was placed a piece of thick lead pipe, 28 mm. high and 25 mm. internal diameter, to ensure that any emanations from the active substance in A would be confined to the inside of the hollow cylinder. The radio-active substance in B was freely exposed to the air, save for a pillar of lead at C, to support the sensitive film. A sensitive film was laid horizontally over the cylinder and support C. On the film was a plate of glass, and cylinder and film were pressed together by heavy weights. The whole was covered in a light-tight box and put in a dark cupboard.

At the end of forty-eight hours the film was removed and developed. There was a strong action shown over cell A (the one covered by the lead cylinder), but over B, the cell exposed to the air, there was no visible impression. Measured in Mr. Chapman Jones's "Opacity Meter"[3] the results were:—

Image over cylinder—Opacity log.[4] = ·79; Opacity[5] = 6·17.

The experiment was repeated, using the same apparatus, but a different preparation of actinium. In this case the exposure was for seventy-two hours. As before, there was a strong impression over cell A and none over cell B. The figures were:—

Opacity log. = ·89; Opacity = 7·71.

These experiments indicate that the electrons from the radio-active agent, chiefly actinium, partake of the properties of a fog or mist of material particles, capable of diffusing away in the free air like odoriferous particles, when not kept in by a thick metal screen.

A further experiment was now tried with the same apparatus, the agent a strongly active radium and barium bromide. This material being self-luminous, a sheet of black paper was placed immediately over it, so that nothing but emanations capable of passing through the opaque paper would be subject to experiment. Afrer four hours' exposure in total darkness, the film was developed. A good circular patch was obtained over cell A, and a faint diffused darkening showed over the rest of the film, darker at the spot immediately over cell B, fading away at the sides as the distance became greater. That this action was due to the material in the open cell B, and not to general fog over the plate, was seen by the clearness of the film where covered by the lead, and where shadows were thrown by the lead cylinder and pillar.

---

[1] By Sir William Crookes, F.R.S. A Paper read before the Royal Society on February 6.

[2] The body I called Uranium X in my Royal Society paper, May 10, 1900, has since proved to be M. Debierne's Actinium.

[3] *The Photographic Journal*, vol. xx. p. 86, December 21, 1895.

[4] The opacity logarithm represents the density of the image, absolute density being represented by 2·00.

[5] The "opacity" is the whole number corresponding to the "opacity log." The "opacity" is directly proportional to the photographic energy acting on the sensitive surface.

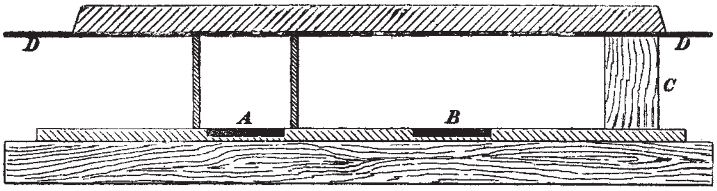

Fig. 1—Elevation.

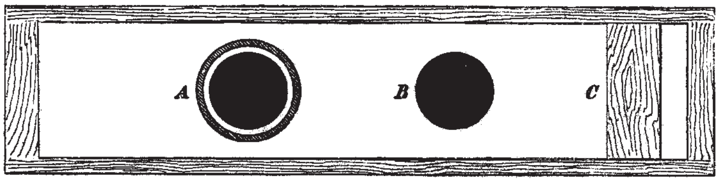

Fig. 1.—Plan.

Circles of the same diameter were drawn round the dark impression over A, and round the darkest part of the impression over cell B. Measurements were taken of different parts of the spaces enclosed in these circles, and the mean of all these came out—

Circle over cell A—Opacity log. = ·53; Opacity = 3·39.
Circle over cell B—Opacity log. = ·32; Opacity = 2·09.
Ratio B/A = ·62.

The experiment was repeated, with the addition of a sheet of aluminium, 0·2 mm. thick, under the black paper, the electrons now having to pass through both paper and metal before reaching the film.

The exposure was for six hours, and the appearance on development was very similar to the last: a dark disc over the protected cell A, and a diffused action over the other part of the film, except in the shadow of the lead supports. Measurements as on the previous occasion gave the following results:—

Circle over cell A—Opacity log. = ·78;
Opacity = 6·03.
Circle over cell B—Opacity log. = ·48;
Opacity = 3·02.
Ratio B/A = ·5.

Finally, I tried polonium subnitrate, which gives off emanations hardly capable of passing through any screen, and greatly obstructed by a few centimetres of air.

The apparatus was substantially the same as the one just described, with the modification that the lead cylinder was 12 mm. high, and at the other end a rod of glass 12 mm. high was used to support the film. The reduced height was chosen, experience showing that polonium emanations have great difficulty in penetrating many millimetres through air. The exposure was seven days, at the end of which time the film was developed. Over cell A a dark disc sharply defined the inside of the cylinder, while over cell B was a hazy diffused patch which to the eye looked much the fainter of the two. But measurements of patch A, and of a disc over cell B of the same size as A, showed that the opacities in each case were practically identical, as shown by the following figures:—

Circle over cell A—Opacity log. = ·74; Opacity = 5·49.
Circle over cell B—Opacity log. = ·76; Opacity = 5·75.
Ratio B/A = 1·05.

A repetition of the experiment, taking the mean of five concordant results, gave the same opacities as before.

Without proving that the emanations from polonium are less material than those from actinium and radium, this experiment shows that their behaviour is entirely different as regards diffusibility through air. Whether this is due to the larger mass of the individual particles, or to the less distance they have to travel (12 mm. as against 28 mm. in the case of actinium and radium), or to some other cause, further experiments must decide.

Dr. Rutherford shows that air which has remained for some time in the neighbourhood of thoria and then is carried in a current to a distance retains its property of communicating radioactivity to other bodies. He explains these phenomena by supposing that thoria gives off a special kind of emanation capable of being conveyed by the air, and that this is the cause of the induced radio-activity.

To ascertain if the electrons or corpuscles from radium also possess the property of being carried along in a current of air I fitted up an apparatus shown in Fig. 2. A, B, and C are three brass tubes closed at the lower end and cemented with paraffin to a wooden block. The upper ends were accurately ground to a level surface and then coated with a thin layer of paraffin wax. Holes were drilled in B and C, to admit glass tubes, cemented air-tight into the cylinders, as shown in the figure. The upper end of the tube in B was closed with a plug of cotton-wool, and the outer end in C was connected to a water-pump, so that when the cylinders were closed at the top a current of air was drawn through B and C. As the radium compound was self-luminous, discs of thin aluminium foil were placed over cylinders A and B to cut off the luminous rays. A sensitive film was laid on the three cylinders over the aluminium, and it was tightly pressed down by a heavy weight, the contact between the film and the tops of the cylinders being sufficient to make the whole air tight. At the bottom of A and B a radium compound was placed, equal weights and equal surface in each. The whole was put into a light-tight box, and air drawn through. The cylinder A was used only as a standard. The air passing into B was expected to carry along with it some of the corpuscles emitted from the active material at the bottom; and the inlet tube in C was turned up at the end, so that the stream of corpuscles-laden air should impinge on the surface of the centre of the film on C, and if it carried with it any radio-active properties the result should be seen on development, by the production of a dark patch. If, however, the air carried no corpuscles, there would be no image on the sensitive film over C.

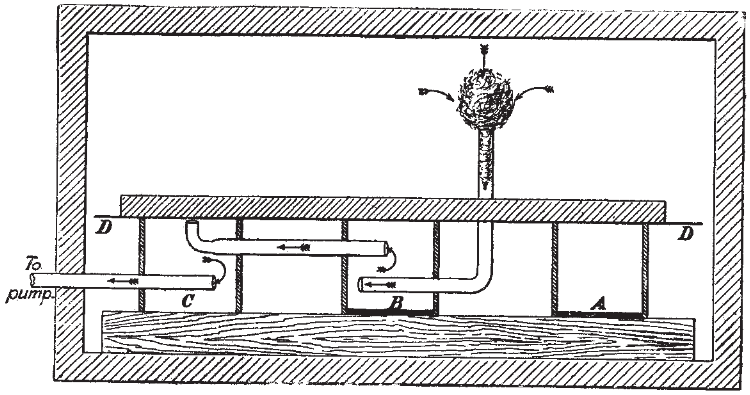

FIG. 2.—Elevation.

The experiment was continued for eleven hours, 120 litres of air having passed through in the time.

On development and measuring the resulting images, the following figures were obtained :—

Circle over cell A—Opacity log. = ·342 ; Opacity = 2·20.
Circle over cell B—Opacity log. = ·178 ; Opacity = 1·51.
Circle over cell C—Opacity log. = ·025 ; Opacity = ·11.
Ratio B/A = ·68.

It thus appears that a current of air passed over the surface of a radium compound carries with it a certain proportion of the corpuscles. This is proved by the diminished photographic action in the second cell, slightly confirmed by the evidence that some few of the corpuscles so carried away get to the sensitive film on cell C. Judging from our slender knowledge of the properties of free electrons, it is highly probable that they will not easily turn a corner, but cling to the sides of the tube through which they are being led. On the other hand, the constant collisions with the atoms of air may reduce their initial mobility almost to a vanishing point before they have travelled along the tube between B and C, and then they would be carried along with the air.

The experiment was repeated, using a preparation of actinium (Uranium X). It was kept going for seventy-two hours, during which time 750 litres of air were drawn through the apparatus. On development and measurement, the following results were obtained :—

Circle over cell A—Opacity log. = ·99 ; Opacity = 9·78.
Circle over cell B—Opacity log. = ·67 ; Opacity = 4·68.
Circle over cell C—Opacity log. = ·25 ; Opacity = 1·78.

Here then the results agree with those tried with radium compounds ; that corpuscles are carried by a current of air from cell B, through the connecting tube to cell C. They also confirm those of Dr. Rutherford—who finds that thorium emanations travel in a current of air while retaining their activity—and of P. Curie and A. Debierne, who show that induced radio-activity can be transmitted through capillary tubes, of an internal diameter of ·1 mm. and 75 cm. in length, bent once at right angles.

I have not obtained, however, a similar result with the emanations from hydrogen peroxide. As shown by Dr. Russell, this substance has a strong action on a sensitive photographic plate. The emanation from a bottle half full of hydrogen peroxide acts strongly on a sensitive film laid over the open mouth of the bottle for twenty-four hours, while there is no action in seventy-two hours if a U-shaped tube passed through the cork of the bottle and the sensitive film is put close to the open end of the tube. Dr. Russell tells me his observations confirm my experiments.

A highly active self-luminous radium compound loses some of its power on long exposure to the ordinary air of the laboratory. When enclosed in glass, the glass soon assumes a pink colour. If, however, the radium compound is sealed in vacuo in a *quartz* tube, no coloration takes place, and I can detect no diminution of energy even in twelve months.

Electrons from radium will pass through aluminium and a considerable length of air and affect a sensitive film.[1] Experiments on this point were tried with polonium, and it was found that air offered great obstruction.

The electron theory explains a fact which has long puzzled experimentalists. It is well known that if a coin is laid on a sensitive plate in perfect darkness and connected with one pole of an induction coil for a few seconds and then developed, an image can be obtained of the raised parts of the coin. This has generally been explained by saying that the electrified stream of air, or the "brush discharge," affects the film like light.

But Mr. F. Sanford (NATURE, vol. lv. p. 485) shows that coins embedded in the centre of a block of paraffin 2 cm. thick, where they could not send off streams of electrified air, can still be photographed by means of the induction coil. In these circumstances it is probable that electrons are the agents, as electrons will easily pass through paraffin wax from the coin to the sensitive plate, when the coin is connected with the negative pole of an induction coil, the other pole being connected with a metal plate placed below the wax block.

Hitherto we have been dealing with negative electrons—a free positive electron at present is unknown. In a paper communicated to the Royal Society, December, 1890 (*Phil. Trans.*, 1901, A, vol. cxcvi. p. 525), the Hon. R. J. Strutt offers a suggestion as to positive ions which in a satisfactory manner appears to explain much that hitherto has been left doubtful, not to say contradictory.

He adopts the generally recognised theory that the deflectable Becquerel rays consist of a stream of negative corpuscles with enormous velocities proceeding from the radio-active body. But there are two kinds of Becquerel rays, one deflectable and penetrating, the other non-deflectable and easily absorbable. Mr. Strutt considers that these non-deflectable rays are positive ions moving in a stream from the radio-active body.

He says :—"We know that the positive ions in gases carry the same charge as the negative, and that they have an enormously greater mass. Unless, therefore, their velocity is smaller out of all proportion than the negative ions, it is to be expected that they will be much less easily deflected by the magnet. . . . Next it may be noticed that the smaller penetrating power would be well accounted for by the size of the positive ions, which would, of course, make more collisions with the molecules of the surrounding gas than the much smaller negative ions."

Of the three radio-active bodies, radium, actinium and polonium, actinium appears to emit corpuscles almost entirely of the penetrating, deflectable kind, polonium rays of the non-deflectable, non-penetrating kind, whilst radium emits rays of both kinds.

On the above hypothesis, corpuscles from polonium might consist of the heavy positive ions : to test the accuracy of this inference experiments are now in progress.

Some curious and far-reaching inferences may be drawn from Mr. Strutt's view, supposing it to be correct, that positive as well as negative corpuscles will fly off from a radio-active body. In a paper "On Electrical Evaporation" (*Roy. Soc. Proc.*, vol. l. p. 88, June, 1891) I showed that many bodies, such as silver, gold, platinum, &c., usually considered non-volatile at ordinary temperatures, easily volatilise in a vacuum if connected with the negative pole of an induction coil, remaining fixed when connected with the positive pole. This phenomenon was first observed by Dr. Wright, of Yale College, and was applied by him for the production of mirrors for physical apparatus. It is shown by experiments that the action in the vacuum tube is of two kinds. A silver pole was used, and near it, in front, was a sheet of mica with a hole in its centre. The vacuum was very high (P = 0·00068 mm.), and when the poles were connected with the coil, the silver being negative, electrons shot from it in all directions, and passing through the hole in the mica screen, formed a bright phosphorescent patch on the opposite side of the bulb. The action of the coil was continued for some hours, to volatilise a certain portion of the silver. On subsequent examination it was found that silver had been deposited only on the mica screen and in the immediate neighbourhood of the pole, the far end of the bulb, at the spot which had been glowing for hours from the impact of electrons, being free from silver deposit. Here then are two simultaneous actions. Electrons, or, as I once called them, "radiant matter," shot from the negative pole and caused the glass against which they struck to glow with phosphorescent light. Simultaneously the heavy positive ions of silver, freed from their negative electrons, or under the influence of the electrical stress, likewise flew off, and were deposited in the metallic state near the pole.

During the course of my experiments a curious circumstance was observed, which deserves record as it may elucidate some of these obscure phenomena. While the volatilisation of the silver pole is rapidly proceeding, the metal glows as if red-hot. This "red heat" is superficial only. The metal instantly assumes, or loses, the appearance of red-heat the moment the current is turned on or off, showing that the high temperature does not penetrate below the surface. The volatilisation of the positive ions is confined to the surface and the surface glow is connected with that action. If instead of silver, a good conductor of heat, I take diamond, a bad conductor, the surface layers are changed sufficiently to convert them into a form of graphite, which from its great resistance to oxidising agents cannot have been formed at a lower temperature than 3600° C.

---

[1] Using an active compound of radium, I have obtained an impression on a sensitive film, through a penny-piece.